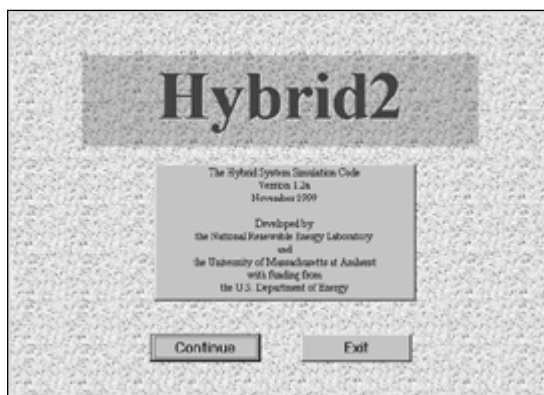# *Hybrid2*: Hybrid Power System Simulation Software

by E. Ian Baring-Gould 12/99

Background

The market potential for renewable-based hybrid power systems is emerging, in part to address electricity generation needs in the developing world. Industry leaders, researchers, and development institutions need an analysis tool to accurately model the performance and economics of alternative hybrid designs. This analysis tool must be versatile enough to model many system locations, widely varying hardware configurations, and differing control options for potential hybrid power systems.

In response to this need, the University of Massachusetts and the National Renewable Energy Laboratory (NREL) developed the *Hybrid2* software. *Hybrid2* is a time-series, probabilistic model that uses time-series resource and load information combined with statistical analysis and manufacturers' data for hybrid system equipment to accurately predict the performance and cost of hybrid power systems. *Hybrid2* allows direct comparison of many different renewable and non-renewable power system designs in a user-friendly format in which off-the-shelf equipment is incorporated into potential power systems. *Hybrid2* was released in June 1996.

Hybrid2 *software.*

Scope

Because of its ability to compare many combinations of power generation options, the *Hybrid2* software is very useful in determining detailed design study performance and hybrid power system upgrades, and in analytical studies on the performance of hybrid power systems. The *Hybrid2* software is used most frequently by private companies, government planners, and research organizations.

The *Hybrid2* code can model many combinations of wind turbines, photovoltaic arrays, diesel generators, power converters, and battery storage in AC, DC, or two-bus systems. *Hybrid2* also allows for more than 100 different dispatch configurations with multiple diesel generators, renewable sources, a synchronous condenser, and battery storage. The model has an easy-to-use graphical interface, an in-depth library to facilitate system design, and a detailed glossary of frequently used terms to assist users who are not familiar with hybrid power system terminology. The software also includes an energy audit tool to assist in determining the load for an unelectrified community as well as a method to enter such data into the model. Time-series data for wind, solar insulation, and temperature can be entered into the software and a data processor is available to fill holes that may occur in the data. The code also includes a comprehensive economics package that incorporates system operation and maintenance costs, equipment overhaul costs, installation costs, taxes, and the system salvage value.

Outputs include, where applicable, useful wind and solar energy, diesel energy, diesel operating hours and start/stops, diesel fuel use, storage system energy losses, and battery life. Economic module outputs include, but are not limited to, life-cycle costing, project cash flow, and investment payback. To ensure code accuracy, *Hybrid2* software has been compared to a number of operational hybrid power systems and has been tested independently. Results are initially positive, but work is still ongoing.

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Status

The *Hybrid2* code was released in June 1996 at the American Wind Energy Association Windpower Conference in Denver, Colorado. The software has undergone numerous updates and is available to the general public in Version 1.2 for a $100 reproduction charge. The University of Massachusetts is providing support for software users and has set up a home page where more software information can be located. *Hybrid2* is used extensively at NREL and over 200 copies have been distributed worldwide. The software package includes:

- Installation disks, Version 1.1 (Windows 3.1 or better) or Version 1.2 (Windows 95 or NT)

- User manual (describes how to construct and run a system simulation)

- Theory manual (describes all of the equations used in the software)

- *Hybrid2* validation report for the Frøya Island data set

Planned Activities

The *Hybrid2* software will be continuously upgraded over the next year with planned releases of updated versions in January and August 2000. Possible upgrades include the modeling of variable speed diesels, variable voltage system architectures to model direct drive devices such as water pumping, and improved resource data synthesis routines.

NREL Contact

Web site: *http://www.rsvp.nrel.gov*
Or
http://www.ecs.umass.edu/mie/labs/rerl

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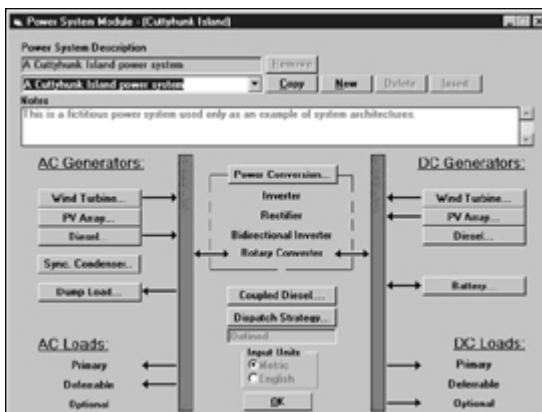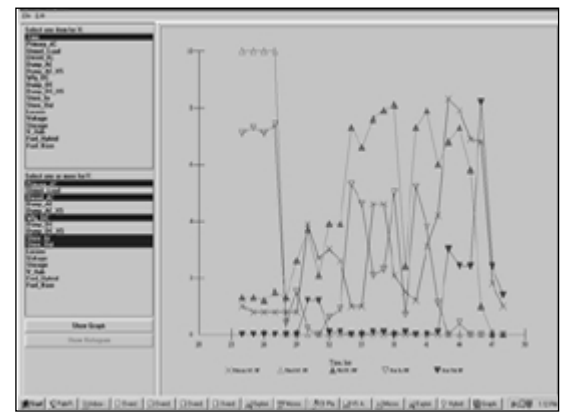
Hybrid2 *software can model many combinations of equipment in AC, DC, or two-bus systems.*

Hybrid2 *detailed output allows analysis of system operation such as the interaction of wind and diesel, shown here.*